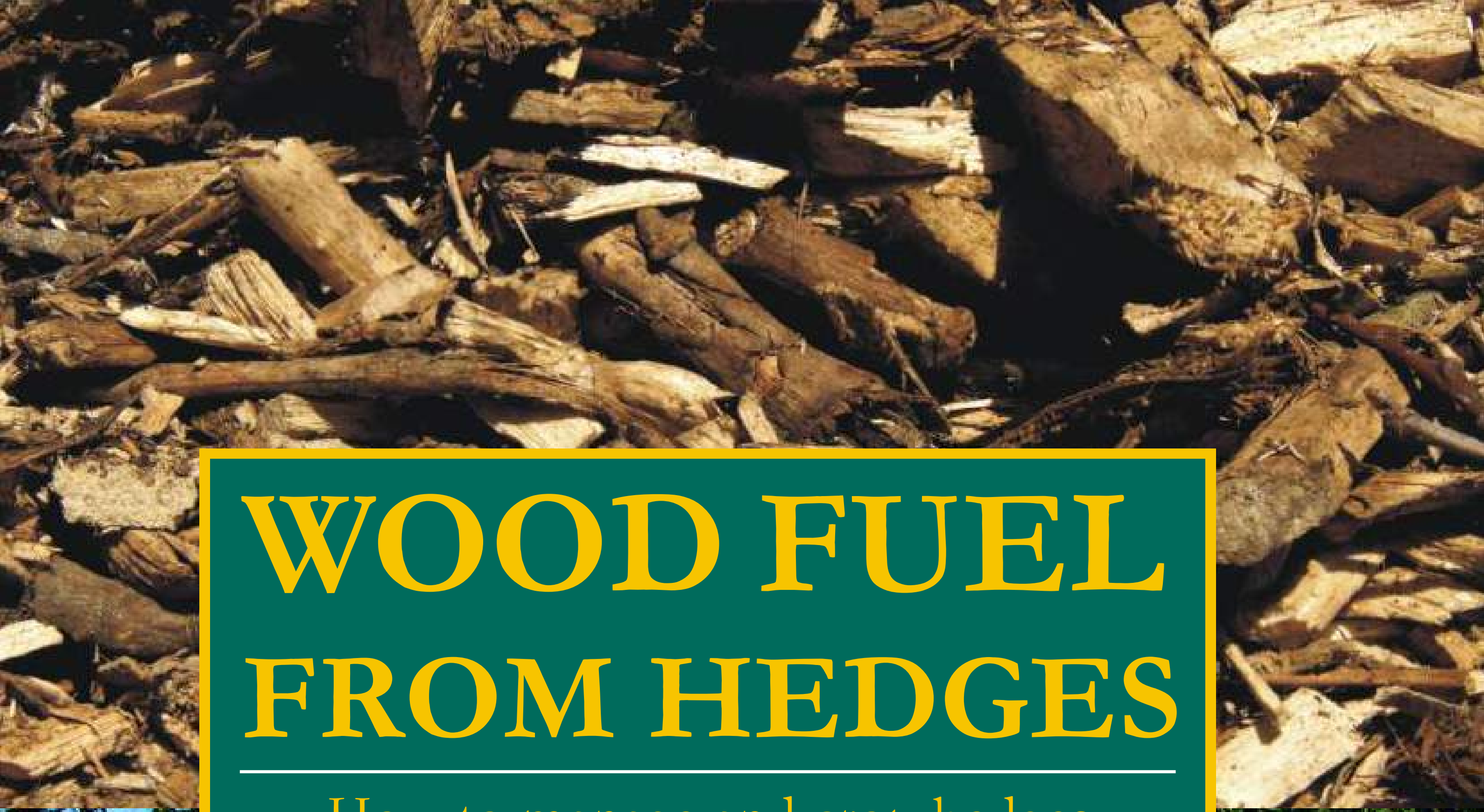
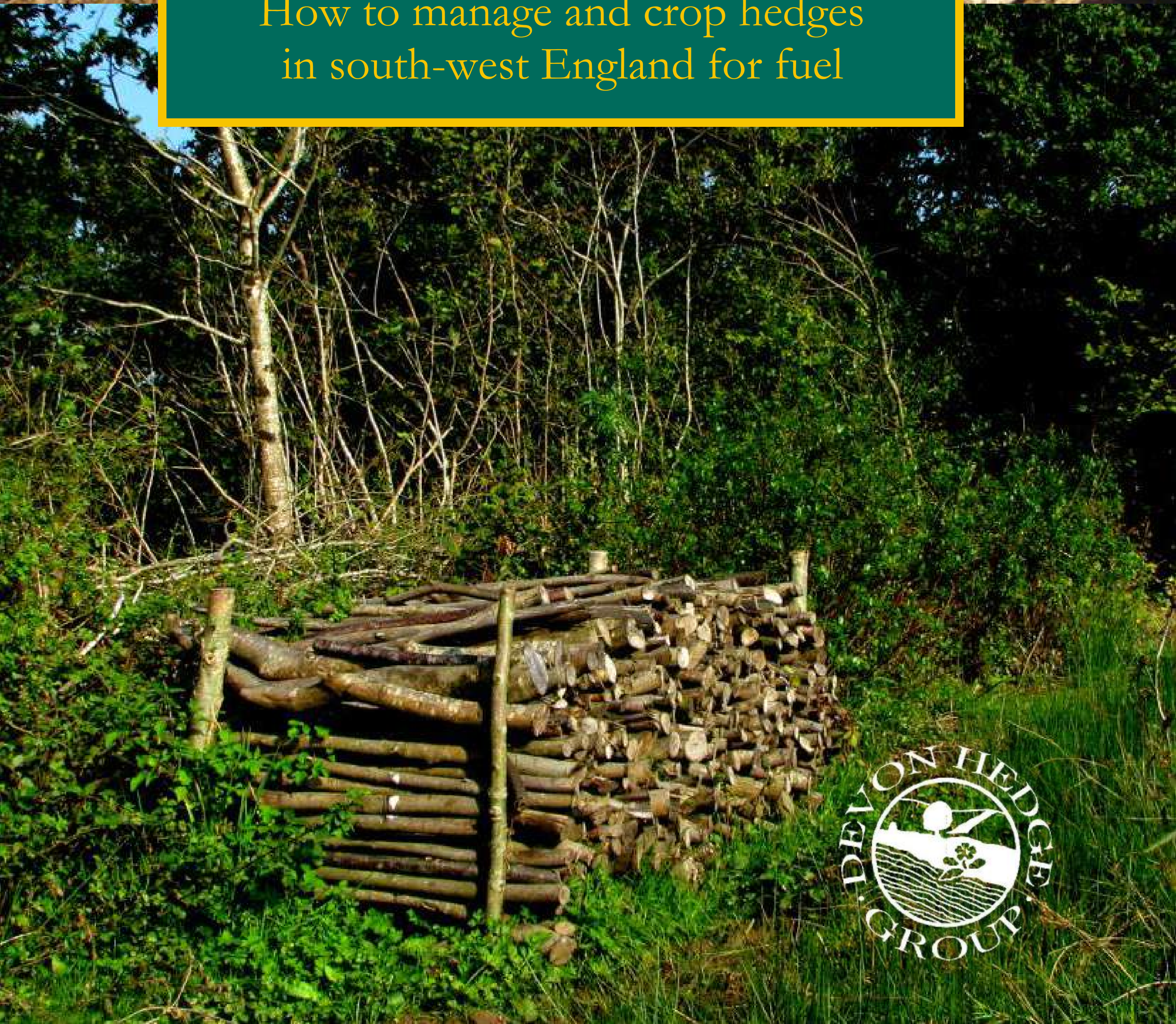


WOOD FUEL FROM HEDGES

How to manage and crop hedges in south-west England for fuel



DEVON HEDGE GROUP

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Foreword

Devon and Cornwall, and our neighbouring counties, have some of best hedged landscapes in Europe and indeed the world. These hedges are well known for their outstanding cultural, scenic and biodiversity value. Less well known is their considerable potential as a cost effective source of renewable energy.

Many farms, probably the majority, could heat at least their farmhouses from their hedges alone and save money in the process, while others will be able to generate an income through selling the wood, as logs or chips, to local communities. Better still, if done well, management to provide a fuel crop will help to secure a brighter future for the region's hedges, alongside reducing greenhouse gas emissions, farm fuel costs and even rural fuel poverty.

This is the first guide to be produced in the UK on how to manage and harvest hedges for fuel. It is based on considerable experience from the other side of the Channel, mainly from Normandy and Brittany in France, as well as on recent research carried out in Devon and Cornwall. Although focussed on south-west England, much of the information contained in this document is, we believe, applicable to other parts of the British Isles.

Corinna Woodall
Devon Local Nature Partnership board,
Wood and hedge lead.

Managing hedges for wood fuel can help ensure that England's world-class hedge networks survive long into the future.
Looking south from Great Torrington, Devon, September 2010.

Introduction

Wood from a coppiced willow hedge with 17 years growth. The cordwood will be cut up and used in wood stoves to heat the farmhouse. Locks Park Farm, Hatherleigh, West Devon, March 2014.

For many centuries firewood from hedges was considered a valuable crop. It was only in the latter half of the 20th Century that this use fell out of fashion because of rising labour costs and ready availability of cheap alternative fuels. Now, with new cost-effective cropping techniques and rising oil prices, it once more makes economic sense to manage hedges for biomass (that is energy , and farmers and others are starting to do so. They see hedges as having a direct economic value, and so the future of hedges becomes more secure with the resumption of positive and sustainable management. Better still, it's a renewable source of energy, helping to mitigate climate change.

Overall, hedges represent a considerable opportunity for farmers to reduce their heating costs significantly while improving the management of hedges. They also present an opportunity for agencies and businesses interested in conservation, countryside heritage and renewable energy. Currently there is a large standing crop available from the many hedges across the region that have developed into lines of trees.

These pages explain how hedges can be managed to produce a worthwhile firewood crop, what yield may be expected, and at what cost. They will help you to decide whether to produce your fuel as logs or chips. The environmental consequences are outlined, and what needs to be done to ensure that wildlife, landscape and public amenity benefit in the long run.

In Devon rough estimates suggest hedges are potentially a source of about the same amount of energy as the county's small (less than 50ha broadleaved woodlands. In fact many woodlands are on steep or wet ground and inaccessible, while most hedges can be accessed for cropping. A detailed study carried out across four parishes in the Tamar Valley, with hedges representative of those across Devon and east Cornwall, found that 59% of available energy from hedges and small woodlands came from the hedges.

There is no suggestion that all hedges should be managed just for fuel. Many, perhaps the majority, should continue to be managed primarily for other reasons, for example as stock proof barriers, for wildlife or the provision of various ecosystem services. Importantly, these hedges can be managed in ways that help to keep traditional skills such as hedge laying alive. In general, across any farm, the aim should be for all hedges to be multi-functional, but with management for some being tailored towards fuel production, others for stock containment or for biodiversity, and so forth.

What types of hedges are suitable for fuel?

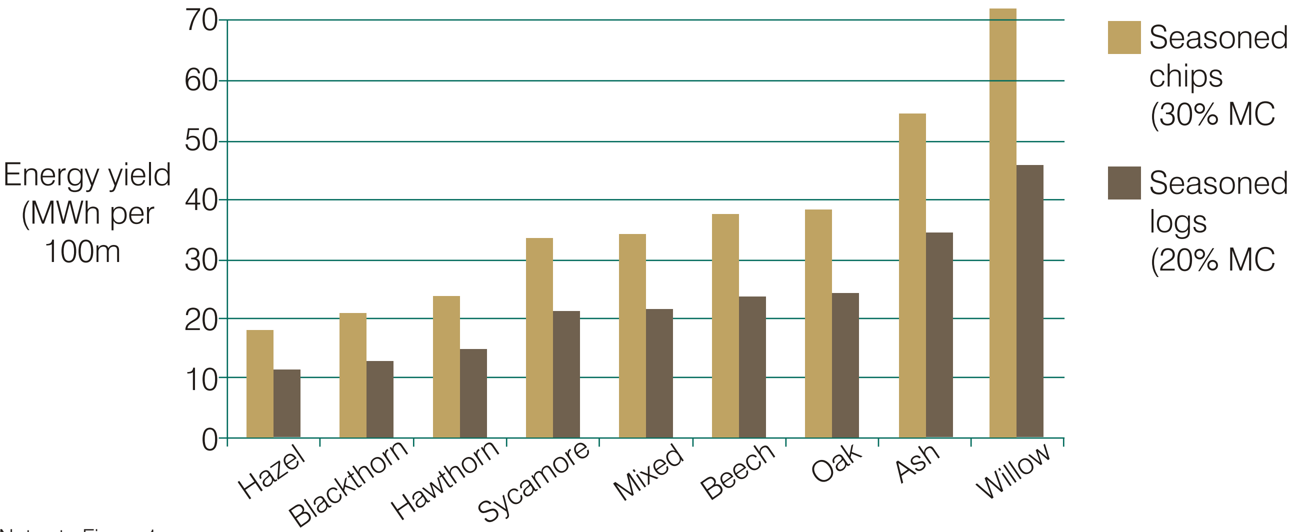
Across large swathes of northern continental Europe there are banked hedges, with similar shrubs and trees to those found in south-west England, that are successfully being managed to produce an energy crop. As a consequence, we have a good idea of the types of hedges can that produce useful crops, confirmed by recent research carried out in Devon and Cornwall.

Most types of south-west hedge can produce worthwhile crops. These include both hedges with a wide range of different trees and shrubs growing on them (species-rich hedges , and hedges dominated by just one species like beech, ash or willow. Of course, they may need to be managed differently from now - short flailed hedges are of little value as they stand, but with the right management many have the necessary ingredients to produce worthwhile biomass crops. Figure 1 gives the expected yields for different types of hedge commonly found in south-west England[1,2,3].

The more trees species like ash, oak, sycamore or willow there are in a hedge, the greater the expected crop. However, even hedges dominated by hazel can produce useful crops, as can blackthorn hedges where the stems have developed exceptional thickness. We do not know much yet about pure hawthorn hedges, but initial results from Berkshire suggest they can produce reasonable crops.

Hedges growing in very wind-swept places, or on thin or infertile soils, are unlikely to be suitable. Conversely, the wider the hedge, the more productive it is likely to be, especially if it has expanded beyond the bank[4].

Figure 1: The expected yield of different types of hedge of average width when managed for fuel.



Notes to Figure 1:
1.Yields vary between species because they accumulate biomass at different rates.
2.The yields given are those expected if the hedge is cropped at the optimal stage for coppicing.
3.Expected yields for logs are less than those for woodchips because small branches and twigs are discarded when logs are produced.
4.Mixed hedges are those with a high proportion of hazel, hawthorn, elm or field maple and a scattering of tree species like oak, ash, beech, sycamore and willow.
5. MC = Moisture Content. MWh = Megawatt hour.

1 All wood, regardless of species, has a very similar energy content, weight for weight, at the same moisture content. Thus one kilogram of seasoned oak will give out the same energy as one kilogram of seasoned willow when burnt. Although different woods have different burning properties, if seasoned properly this is of minor significance except perhaps in open fires which are not recommended because they are highly inefficient in comparison to stoves or boilers.

2 Ash typically has a moisture content of 33% when green, hazel 44%, hawthorn, oak, beech and sycamore 47%, elm 58% and willow 60%.

3 The densest woods when completely dry are oak, beech and hawthorn (c. 550kg m^{-3} , followed by birch and ash (530kg m^{-3} , sycamore 490kg m^{-3} and elm 430kg m^{-3}. Willow is the least dense, at 350kg m^{-3}.

4 The average width of a hedge bank in south-west England across its top is about 1m. Across its base it is likely to be 2m or more wide. Shrubs and trees frequently grow on the sides as well as the top.

The management of hedges to produce biomass for energy

To produce a good fuel crop, hedges need to be managed differently from the way most currently are. In particular, they need to be allowed to grow freely upwards: top trimming should be avoided. Side trimming, to prevent any loss of field cropping area, will reduce yields slightly but may create better wildlife habitat. At harvesting time, trimming back any low outgrowths of bramble, blackthorn or other growth may make cropping easier.

Top trimming should be avoided where hedges are being managed for fuel, although side trimming is acceptable. Hedges that have been repeatedly flailed and are gappy and lacking in vigour usually need cutting down to the ground and allowed to re-grow before they can start to produce useful biomass for energy.

Hedges for fuel should usually be allowed to grow 5-8 years past the stage when they are ready for laying, to the stage when they are ideal for coppicing. This is typically when the trees and shrubs are 6 - 7m high, and the larger stems are 15 - 20cm in diameter. When still at the laying stage, hedges can produce a fair quantify of small round wood suitable for cutting into logs, but this will normally be considered a by-product of a good stock proof boundary rather than a cost effective crop, as explained below.

Where hedges have been flailed short for many years, the stems are likely to have lost their vigour. Under these circumstances, rather than wait for the hedges to grow up to a state where they are ready to coppice, which may take a long time, it is probably better to cut them back to ground level straightaway, to promote the growth of vigorous young shoots, probably discarding the cut material as waste.

It is not normally good practice to allow hedges to develop into lines of mature or semi-mature trees before they are harvested. This is partly because many of the shrubs will be shaded out within tree lines creating gaps, reducing the environmental value of the hedges as well as putting the bank at increased risk from erosion. It is also because large trees risk damaging the bank, either through their roots rocking and breaking up the bank when the tree is blown by the wind, or by pulling the bank apart when the tree blows over. Quite apart from such wind rock and wind throw, large roots can push banks apart. In addition, yield spread over several cropping cycles is likely to be reduced. Nevertheless, if a hedge has already developed into a line of mature or semi-mature trees it is likely to contain a lot of wood which can be harvested. Be aware though that some stools, especially those left behind after old trees have been felled, may not re-grow and it is likely replanting will be necessary along with bank restoration before the hedge is once more in a healthy state.

Hedges managed without top-cutting and by coppicing will be less well protected from grazing animals than those which are cut regularly and laid. The banks in particular will be more vulnerable to damage through livestock trampling, and the new growth at risk from rabbits, deer, etc. In practice it is often possible to coppice most of the stems in a south-west banked hedge but still lay enough of the smaller ones to create a stock-proof boundary or for wildlife reasons. It remains likely, though, that coppiced hedges will need to be fenced on stock farms, but fencing is normal practice nowadays even after hedge laying, so managing for fuel may not add to costs in this respect. If coppicing is carried out at 15 - 20 year intervals, as recommended, this fits in well with the expected life of treated wooden fence posts. However, if fences are expected to last for longer, then they should be set well away from the bank, to facilitate future cropping.

Hedges should normally be cropped for fuel when ready for coppicing, typically 5-8 years after they are ready for laying. Above: coppicing a hawthorn stool. Below: coppiced hazel stool.

Planting new hedges for fuel

Farmers and landowners may wish to plant new hedges with the main aim of producing biomass for energy (although they will still have other uses such as providing wildlife habitat or even supplementary fodder for livestock . Such hedges are best placed on reasonably fertile soils in places with good vehicular access, and planted with a high proportion of species that accumulate biomass rapidly such as willow, poplar or alder. For more multi-functional hedges, other species such as hazel, sycamore, sweet chestnut and oak should be added to the mix.

Biomass hedges can be used between strips, or alleys, of other crops, as practiced in some agro-forestry systems, the hedges being managed as short-rotation coppice (SRC . If managed as SRC, then the first crop may be taken between 3 and 6 years after planting. Farmers may wish to seek specialist advice before planting new hedges for fuel.

Legal considerations

A Felling Licence will be necessary from the Forestry Commission before coppicing a hedge if stems are to be felled which are 15cm or larger in diameter at breast height (1.3m and more than 5 cubic metres are to be felled in any calendar quarter (reducing to 2 cubic metres if any of the wood is to be sold . 5 cubic metres equates roughly to 20 to 40 larger stems (15-20cm diameter, 6-7m high in a hedge of optimal coppice size, or to one mature oak tree (diameter 60cm, 15m high .

For farmers in England claiming under the Single (Basic Payment Scheme, Good Agricultural and Environmental Condition (GAEC 15 currently (April 2014 permits hedge laying and coppicing until the end of April. However, many birds start breeding in March, so preferably all such work should be completed before 1 March. It is an offence under wildlife legislation to knowingly or recklessly destroy or damage any bird nest. Where hazel dormice are known or suspected to be present, special precautions must be taken to avoid breaking the law - see the guidance prepared by the Devon Hedge Group in the booklet Devon's Hedges.

It is not normally necessary to apply for consent under the Hedgerow Regulations 1997 before coppicing a hedge, provided cut stools are given adequate protection and allowed to re-grow. If the intent is not to allow the hedge or any part of the hedge, however small, to re-grow, then a notice of intent to remove must be submitted to the local planning authority under the Hedgerow Regulations.

Planning consent may be required for new banked hedges. Although the construction of new banked hedges might be considered to be permitted development, it is sensible to consult your local council before starting such work. Where materials are to be imported on to your land for this purpose, it is necessary to seek a waste management licence exemption from the Environment Agency.

New Devon hedges like this may be planted to provide a woodfuel crop.
Wonnacott Farm, West Devon. Photo: Rosie Yells.

Crop type - logs or chips?

A key choice for farmers and landowners is whether to produce logs or woodchips from their hedges. This section presents the pros and cons of these two alternatives.

Logs can be burnt in open fires, wood stoves, ranges or log boilers. However, in comparison to woodchips, they are much more demanding of time and muscle all the way from processing the stems extracted from a hedge to feeding logs into the fire. The wood must be transported from the hedge to a store to dry for at least a year. Either before or after transport, stems must be cut and split into the right sized logs, by saw and axe, or more easily with a firewood processor[5]. Finally these logs must be carried from the store to the fire. As the saying goes, logs warm you four times over - when you cut down the trees, when you cut and split them into logs, when you carry them to the fire, and finally when they burn.

When usable logs have been cut from the growth extracted from a hedge, the remaining small branches and twigs (the brash are usually disposed of in a bonfire. If a hedge is harvested when it is at the laying stage, as much as 70% of the extracted biomass may be wasted in this manner (and this assumes all stem and branch wood 5cm or more in diameter is used . Even at the coppicing stage, the proportion wasted is likely to be about 40%.

Chips can be produced much more efficiently than logs in terms of time, labour and cost. Also, 100% of the harvested material can be used[6]. On the downside, woodchip boilers are three or four times more expensive to buy and install than log boilers. More information is given on how to produce chips efficiently from hedges in the next section.

Brash being burnt after hedge laying. About 80% of total available biomass, and therefore energy, was wasted, either as steepers (laid stems retained in the hedge or in the bonfire. Locks Park Farm, Hatherleigh, West Devon, December 2008. Photo: Paula Wolton.

Table 1 compares the time and costs incurred when laying and producing logs (the Lay + Log system , with those incurred when coppicing and producing logs (the Coppice + Log system , or coppicing and producing chips (the Coppice + Chip system . Laying is clearly much more time consuming than coppicing, and furthermore a substantial proportion of usable material is often retained in the hedge as the laid stems (steepers , perhaps 10-20%. Processing logs ready for combustion from extracted material is also much more time consuming than processing chips.

Table 2 gives a summary of the factors that need to be considered when deciding whether to go for logs or chips. Woodchip systems require substantial capital investment and machinery, but much less physical effort and time than logs, and are most likely to be suitable for the larger houses and associated buildings typical of farms, especially if these are being newly constructed or substantially renovated. Log systems, on the other hand, are cheaper, require less space, and so are more likely to be suitable for smaller premises, in particular older houses. If the fuel is to be sold, clearly it will need to be produced in a form that meets target market demand.

5 A wood processor is a machine, typically powered by a tractor, into which stems are fed, by hand or conveyor belt, and which cuts and splits the stems into logs of the desired size.

6 Twigs and bark have much the same energy value by weight as other forms of wood, although bark produces more pollutants and residue if not burnt at high efficiency.

Table 1: Labour time and processing costs for different hedge harvesting methods.
This is a rough guide only: hedges vary greatly in growth form, width, continuity and accessibility.

System	Time for 100m of hedge (hours				Cost of processing per hr (£
	Laying/coppicing	Processing	Transport	Total time	
Lay + Logs	56 with chainsaw, manual handling	28 with chainsaw and axe	3	87	16 (hourly rate for labour
Coppice + Logs	8 with chainsaw and grab	16 with wood processor	3	27	35 (hire & operation of processor
Coppice + Chip	8 with chainsaw	16 with whole tree chipper	1	10	200 (hire & operation of chipper

Table 2: Factors to consider when choosing whether to produce woodchip or logs

	LOGS	CHIPS (Continental System	Comments
Time and effort to process and harvest (see also Table 1	Small branches etc. must be removed from stems. These in turn must be sawn and split into right-sized logs.	Can be made very quickly with no manual handling required.	Logs are likely to take 8-9 times more hours to produce than chips, and much more physical effort - but keep you fit! Wood processor use will reduce the difference.
Equipment requirements	Only a chainsaw, but a wood processor makes cutting and splitting into fire-ready logs safer and faster.	Chainsaw (or an excavator-mounted feller-buncher for coppicing, whole tree chipper, and trailer for chip transport.	Handsaws (e.g. bow saws can be used instead of chainsaws but require much more effort and time. Feller-bunchers, chippers and trailers can be hired.
Drying	Stems can be dried in piles outside, but better to season logs under cover. Drying takes at least a year, and often two or even three.	Well-ventilated covered shed with a flat, sealed, floor required. Self-drying takes 3 - 4 months.	Logs need to be dried to 20% or less moisture content for efficient combustion, chips only to 30% - 35%[7]. A waterproof but breathable fabric can be used to cover chips if no shed is available.
Biomass wastage	Brashwood is not used - perhaps 40% waste.	Whole trees and bushes used - no wastage.	The use of branch loggers can substantially reduce waste if logs are main fuel.
Combustion methods	Open fires, wood stoves, ranges, log boilers.	Woodchip boilers.	Logs can be used for cooking (in ranges , chips cannot.
Time and effort required to keep fire, stove, range or boiler going	Wood has to be carried from store to fire, the fire fed and ash removed frequently.	Woodchip hopper typically requires filling once every 3 months (depending on its size and ash removing once a month, otherwise process fully automated.	It is possible to have an automated feed for large log boiler systems. Fires, stoves and ranges require much attention.
Likely cost of boiler for an average farmhouse	£8,000	£30,000	Public support payments for renewable energy (e.g. the Renewable Heat Incentive may allow these costs to be recovered in 7 years or less.

7 Moisture content can be assessed either by using a commercially-available moisture meter or more accurately by weighing the wood before and after drying. Moisture meters frequently produce inaccurate readings. The moisture content of logs can often be adequately assessed by their weight in the hand and extent of end grain splitting. The figures given are calculated on Wet Basis - see Biomass Energy Centre site for further information.

Branch loggers

Branch logger in use. Elm Farm, March 2014.

The use of machines called branch loggers shows promise, spanning the divide between chips and logs. These machines resemble chippers, only they cut whole branches into short (about 10cm lengths, twigs and all, so all available biomass can be used in stoves, ranges or log boilers. The material can be fed directly into mesh bags for air seasoning and easy sale. If twigs are included this product is particularly useful for starting fires, otherwise the small logs are popular with those who have small stoves at home. The economics and sustainability of this have yet to be fully assessed, although early signs are promising.

How green is hedge wood fuel?

Beech hedge harvested at coppice stage for logs. Most stems have been coppiced, but a few smaller ones have been retained and laid.
Way Close, Madford, Blackdown Hills. January 2012.
Photo: James Biggs.

Figures from Normandy show that for every one unit of fossil fuel used to operate the Coppice + Chip system, 44 units of renewable energy are produced a ratio higher than for Short Rotation Coppice (1:33 or Miscanthus (1:27 . Such figures for the Lay + Log system are not available, but since the only fossil fuel likely to be used is for chainsaws and on-farm transport, will be even more favourable than for the Coppice + Chip system.

Managing hedges for fuel is likely to have a positive impact on climate regulation, through increasing the amount of carbon they store and through offsetting greenhouse gas emissions from fossil fuel use.

Producing woodchips efficiently

Continental system

This is probably the most efficient way of producing chips from hedges. First, after the leaves have fallen, the growth is coppiced with a chainsaw and the whole cut tree or bush is then lifted clear with a tractor-mounted grab (crane and placed in a row alongside the hedge. Much quicker still, the coppicing can be done with a feller-buncher head mounted on an excavator (see photo . This type of head, which is used widely in commercial forestry, cuts one or more stems off at the base, grabs them and lifts them clear. The head cuts with a rotary saw blade, a chain saw bar, or a pair of powerful pincers or shears. The last is preferred by most contractors because it is not easily damaged by stones, wire, or other debris. However, it tends to split and fracture the cut stools and needs to be used with caution - one solution may be to cut high and then cut off the damaged ends with a chainsaw. However, saw blades or bars are preferable.

Hedge tree felled and being lifted clear by an excavator with feller-buncher head.
Kries Steinfurt, Germany. Photo: Benedikt Brinkt.

Within a few months, when the ground is firm enough and the machinery available, a large chipper is brought onto the site and the whole trees and bushes fed into it with tractor-mounted grab. These machines can cope with anything from twigs through to trunks 30cm or more in diameter. The chips are blown straight into a trailer such as a silage wagon and taken to the drying shed. Here the chips self-dry as explained below. They are then ready to be taken to the hopper that feeds a woodchip boiler.

Whole tree chipper in operation. Previously the hedge had been coppiced and the trees and bushes laid in a line beside the hedge. 100m of hedge can be chipped in one hour!
St. Amand, Normandy, February 2012.

In parts of Devon and Cornwall the ground is unlikely to be able to support heavy machinery during the winter months. This will limit the use of tractors and excavators, and is an important factor to consider.

Woodchip drying and quality

Chip drying is easier than generally believed. All that is needed is a shed with a clean sealed floor and open on at least one side allowing good ventilation. Here the chips are placed in a heap. Fermentation rapidly commences, the heat generated drying the chips in 3-4 months, reducing the moisture content from about 50% to the 30-35% required by woodchip boilers. In the process about 15% of the biomass (and therefore energy is lost, but there is no need for any external heat source. Even small heaps a metre or so high will self-dry in this manner, though larger heaps perform better. It is advisable to keep heaps less than 10m high to minimise any risk they will burst into flames. No green material such as leaves or needles should be placed in the heap, otherwise it may produce compost rather than clean chips - evergreens such as most conifers and holly should not be used. Also, it is advisable, if possible, to mix chips from species with high initial water content such as willow and poplar with those from drier species. There is no need to turn heaps, nor is there any effluent run-off. If no shed is available, then the heap may be covered with a breathable fabric that keeps rainwater out but allows moisture to escape, although this has not been adequately tried and tested in the West Country.

Modern woodchip boilers are highly efficient, performing nearly as well as condensing oil burners, at over 90% efficiency. They produce remarkably little ash, perhaps a dustbin full after a full season of heating a farmhouse. Quality makes are highly reliable and nearly as simple to operate as oil burners. They are self-feeding through an auger drive from the hopper. Problems are only likely to arise if poor quality chips are used, especially if pencil-shaped chips, or shards, are present. For this reason, only fuel-grade chippers should normally be used, which sieve out shards. Critically, it is important to match the fuel grade to the boiler. Large boilers are generally more tolerant of chips of inconsistent size and shape than small ones. Machines that shred rather than chop or cut wood into pieces are unlikely to produce chips of adequate quality.

Woodchip drying shed and store at the back of a farmhouse heated with woodchips from farm hedges. The chips self-dry through fermentation. La Tournerie, Raids, Normandy, February 2012.

Other ways of producing chips

There are other ways in which chips can be produced, although these may be less cost-effective than the method described above. One good example is where whole trees and bushes are placed in a heap and air dried before being chipped. The advantages of this are that a heavy chipper does not need to be taken out into fields, the trees being transported off site close to the boiler with a forestry forwarder (or trailer and tractor-mounted grab . In addition, there is no need for a separate chip drying shed, the chips being blown straight from the chipper into the feed hopper for the boiler. Furthermore, there is no loss of biomass during the drying process due to fermentation and it may be possible to achieve lower moisture content. However, wear on the chipper will be greater, chip quality will probably decline and adequate seasoning may be difficult to achieve in a wet summer.

A variation on this system is to chip only the air-dried cordwood arising from hedges. The advantage of this is that a large whole tree chipper is not necessary, adequate machines being readily available from local machinery hire centres. However, the brashwood will have been wasted and much more manual handling is likely to be required. As noted above, the wear and tear on chippers is greater and chip quality likely to suffer when using seasoned wood as opposed to green wood.

Young trees air drying prior to chipping with whole tree chipper. The shed behind houses a boiler and chips are blown direct from the chipper into the feed hopper. Whitemoor Farm, Doddiscombsleigh, Devon, Feb. 2014.

Discussing the wood fuel crop of a hedge. Both a quick appraisal chart (see Table 3 on page 14 and on-line detailed assessment tool (see Resources are available to help estimate likely yield from hedges.
Collacombe Barton, Lamerton, Devon, March 2013.

Expected yields and length of hedge required

The biomass, or energy, yield of hedges will vary greatly according to their continuity (that is the extent of any gaps , species composition (see Figure 1 on page 3 , stage of growth, the degree of exposure and the fertility of the soil. As a rule of thumb, 100 metres of banked hedge with no gaps growing on reasonably fertile soil in a fairly sheltered place, when coppiced and chipped, will yield 1-2MWh of energy each year over a 15 to 20 year cycle[8]. It will only yield about one fifth of this if the hedge is laid and logged, over an 8 to 12 year cycle.

A rough estimate of the standing biomass and available energy in hedges at different growth stages is given in Table 3 on page 14. This assumes complete growth (whole tree harvesting and takes no account of species composition or site conditions. Examples of likely yield (either as logs or chips from different types of hedge frequent in Devon and Cornwall are given in Table 4 on page 16.

More accurate estimates of yield may be obtained by using the Whole Farm Hedge Fuel Assessment Tool available at www.devon.gov.uk/hedges. Use of this tool requires assessment of the growth stage of the hedge under assessment, its main species, the extent of any gaps along its length, and an estimate of its vigour (reflecting levels of soil fertility, altitude, wind exposure and shade . The estimated yield is given by weight, volume and energy, both for chips and for logs.

A typical four-bedroom, leaky, farmhouse requires about 35MWh of heat each year. This is equivalent to 10 tonnes or 40 cubic metres of seasoned chips, or 8.5 tonnes or roughly 26 cubic metres of loose-stacked seasoned logs. It follows that between 100m and 200m of hedge need to be cropped each year, on a 17-18 year coppice cycle, to heat such a farmhouse on the Coppice + Chip system. In contrast, with the Lay + Log system, some 500m to 1km will be needed. These figures show that the Lay + Log system is only likely to be suitable for premises where wood from hedges is complemented by fuel from other sources, for example from farm woodlands or from purchased oil.

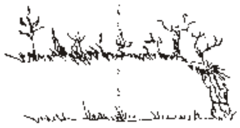
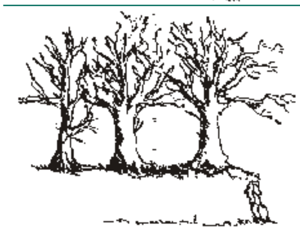
Taking 150m as the average length of hedge that needs to be harvested each year under the Coppice + Chip system, then on a 17-18 year coppice cycle, 2.6km of hedge will need to be managed for fuel to heat the typical farmhouse, say 3km to be on the safe side. (As explained below, for environmental reasons not all hedges on a farm should be, or can be, managed primarily for fuel, so a farm will normally need at least twice this length if it is to provide all the chips needed to heat the farmhouse sustainably from hedges alone.

If, as is so on many farms, hedges have been permitted to develop into lines of trees, then in the early years of using hedges for fuel, a shorter length of hedge may need to be harvested than in later years. Hedges that have grown past the optimal coppicing stage into lines of semi-mature or mature trees will generate much more fuel on first cropping, typically between 2 and 4 times as much.

If a farm does not have the necessary length of hedge to meet its heating needs, either in any particular year or over a full coppice cycle, then chips can be harvested from any woods on the farm or bought in. This will still be more cost effective than using oil or gas. In fact, most farms in south-west England have more than 10km of hedge, so once they are under the correct management should be able to heat at least the farmhouse on a sustainable basis from hedges alone.

8 An "average" hedge may be expected to accumulate around 0.5 tonnes of seasoned biomass (at 30% MC each year per 100m on a whole tree or bush basis. This is equivalent to 1.75 MWh (or about 7 cubic metres of woodchips . Biomass accumulation will, however, vary considerably according to species, exposure and soil fertility. After about 20 years, hazel shows no further increment - this may be true of other shrub species.

Table 3: Quick appraisal of the standing biomass and available energy in different hedge types. Illustrations by Heather Harley. See also photographs opposite.

	Illustration	Description of hedge type	Volume of green chips per 100m (m^3	Weight of green (45% MC chips per 100m (tonnes	Energy content of seasoned (30% MC chips per 100m (MWh
1		Bare bank with woody shrubs absent or less than 1m high - typical of hedges in very exposed places, or which are cut very short, or which have been recently planted.	0	0	0
2		Shrubs are 1-3m high and 2-3m wide - typical of flailed hedges.	6.5	2	5
3		Shrubs are 4-5m high and wide - typical of hedges ready for laying. The larger stems present will be 10-15cm in diameter.	20	6	15
4		Shrubs are 6 -7m high - typical of hedges ready for coppicing. The larger stems present will be 15-20 cm in diameter.	40	12	30
5		Woody stems over 8m high, appearing as a line of semi-mature trees, often with a shrub layer beneath. The larger stems present will be 20-25 cm in diameter.	80	25	63
6		Line of mature or nearly mature trees (often with no shrub layer beneath due to dense shade .	165	50	125

Notes on Table 3.
1. Only the current standing crop, not the potential crop is assessed.
2. Figures are based on completely cutting down the growth (i.e. coppicing it and chipping it all.
3. Note that the figures are per 100m of hedge. Adjustment will need to be made for the actual length of hedge assessed and any gaps within it.
4. It is assumed that mature hedgerow trees are retained where these are either isolated (i.e. canopies do not touch or contain veteran features (e.g. hollows and rot holes .
5. MC = Moisture Content. MWh = Megawatt hour.

These six photos show the major points in the hedge management cycle that need to be recognised before a hedge's standing woodfuel crop can be estimated (see Table 3, opposite .

1 Hedge consisting of a bank only. Speke's Mill Mouth, Welcombe, Devon, October 2010.

2 Typical flailed south-west England hedge. Highampton, Devon, September 2008.

3 Typical hedge ready to be laid ('Point of Lay' ,4-5m high. Underdown Farm, Yarcombe, Devon, January 2012.

4 Typical hedge ready to be coppiced ('Point of Coppice' , 6-7m high. Higher Hampt Farm, Luckett, Cornwall, January 2012.

5 Typical hedge developed into line of semi-mature trees, 8m+ high. Cotley Farm, Axminster, Devon, December 2011.

6 Beech hedge which has developed into line of mature trees, 8m+ high. Meldon, Okehampton, Devon, April 2009.

Table 4: Expected yield from different hedge types and field conditions harvested at either coppice stage or when ready to lay[9,10]

Hedge type	Energy yield under different cropping regimes (MWh per 100m		
	Coppice + Chip	Coppice + Log	Lay + Log
Mixed hedge in fertile and sheltered place	34	22	5
Single species beech hedge in fertile and sheltered place	38	24	6
Single species beech hedge growing in exposed upland conditions	19	12	2
Hedge with much ash in fertile and sheltered place	55	34	7
Hedge dominated by willow in fertile and sheltered place	72	46	9
Blackthorn hedge growing in exposed coastal situation	7	4	1

Production costs

The costs of producing woodfuel from hedges, and unit costs of the energy obtained, will vary considerably according to biomass yield and method used. The accessibility of the hedge will also have an influence. Typical unit costs of energy from hedges and other sources are given in Table 5, opposite.

As already described and as Table 1 on page 8 shows, producing chips takes much less time than producing logs. A man with a chainsaw can harvest 100m of hedge in a day, if the cut trees are lifted out by grab or crane. A feller-buncher can do the same job in just an hour or two! The trees and bushes can then be chipped within an hour. So, if chips are produced, it is possible to meet a typical farmhouse's heating fuel needs for a year in a single day's worth of work, including transport times, though that work will need to be spread across several months.

On the other hand, hiring the machinery necessary for efficient chip production is not cheap - an excavator with a feller-buncher head is likely to cost £60 an hour (if one can be found and a whole tree chipper £200 an hour (at 2014 prices , and these figures exclude transport costs which may be substantial. Even so, the cost of the resulting energy is typically just 2-3 pence per KWh.

9 1 tonne of seasoned chips typically occupies 4 cubic metres, although this will vary with wood density. The tonne will generate close to 3.5MWh, regardless of species, at 30% moisture content.

10 1 tonne of seasoned logs typically occupies 3 cubic metres when loose stacked, although this will vary with density. The tonne will generate close to 4.1MWh at 20% moisture content.

Table 5: Typical unit costs of energy, by fuel, December 2013[11]

Fuel	Pence per KWh	Comments
Coppice + Chip system - on farm (see Table 1 for methods	2 - 3	Coppicing with a chainsaw may be as cost effective as using a feller- buncher, but is more time-consuming.
Coppice + Log system - on farm (see Table 1 for methods	4 - 8	
Lay + Log system - on farm (see Table 1 for methods	15 - 30	
Bought in wood chips (30% MC	3.1	Based on bulk order of 10 tonnes. If chips have to be blown into store they will be more expensive. Prices vary considerably between suppliers - this is mean UK price.
Bought in logs (20% MC	3.5	Based on bulk delivery of about 1 tonne of loose hardwood logs - small bags of logs will cost more. Prices vary considerably between suppliers.
Wood pellets	4.4	Based on bulk order of 5 tonnes. If pellets purchased in bags, they are likely to be significantly more expensive. Prices may vary considerably between suppliers - this is mean UK price.
Natural gas	4.9	
Heating oil	5.8	
LPG (bulk	6.5	
Electricity	15.0	

Notes on Table 5.

1. Hedge figures take into account all costs from harvesting right the way through to combustion, including labour, machinery hire and fuel. Labour is costed at £16 per hour for all operations involving the use of hand tools only (including chain saws , increased to £24 per hour if tractors or wood processors are used to reflect the cost of running such machines.
2. Figures do not take into account combustion efficiency, but the effect of this will be small if boilers are used since modern appliances, whatever the fuel, should run at more than 90% efficiency. (The efficiency of stoves will usually be less, and of ranges considerably less.
3. All figures assume no direct public support payments to the user, such as payments to coppice or lay hedges under an agri-environment scheme, or for the generation of renewable energy. If such payments are available, then they will considerably reduce costs.
4. Hedge figures do not include any fencing costs.
5. Hedge figures also do not take account of any savings that may arise as a result of not trimming hedges (by flail . Such savings may be substantial.

Cooperative hedge woodchip drying and storage shed at Saint Samson-de-Bonfosse, Normandy, February 2012. Local farmers share resources to harvest wood from their hedges and provide the local community with the resulting woodchips. The pale chips on the left have recently been delivered and are self-drying through fermentation heat, the darker ones on the left are dry and ready for use.

[11] Source: Woodchip and log figures from author's calculations, bought in logs from information supplied by Ross Dickinson, all other figures from Biomass Energy Centre Fuel costs per kWh (December 2013 at http://tinyurl.com/5oet6d

Impact on wildlife, landscape and public amenity


Hazel dormouse in a managed hedge. Hedges not kept thick and bushy by regular cutting are poor nesting habitat for dormice, but produce more berries and nuts for them to eat.

Managing for woodfuel can help, at a landscape scale, to ensure that the world-class networks of hedges found in the south-west of England remain intact into the future. It will counter the two current prevailing trends of either cutting hedges repeatedly to the same height year after year or of neglecting them altogether: both these trends lead eventually to the loss of hedges. However, in the shorter term, managing for woodfuel can have harmful impacts on the wildlife of individual hedges and perhaps on the appearance of the landscape and social amenity (e.g. public access and views from private properties . These impacts need to be assessed and mitigated.

The absence of top trimming has a profound effect on hedge structure. Hedges left to grow uncut rapidly become leggy and lose the dense structure favoured by much wildlife. Most small birds strongly favour thick, bushy hedges for nesting in, and the same is true for hazel dormice. On the other hand, trees and bushes that are not cut flower better, and produce heavier crops of berries and nuts. Any woodland ground flora present on hedge banks is also likely to respond well to being managed under a coppice cycle. Probably, on balance, hedges that are not trimmed at any stage support less wildlife than those that are kept thick and bushy by cutting. Side trimming can help to redress this.

Immediately after coppicing, hedges are bare and inhospitable places for much wildlife, although this effect only lasts for a year or two. Recently coppiced hedges are effective breaks not just in habitat but also in the highways that many animals, from grass snakes and lizards through to dormice, hedgehogs and bats, use to move and navigate around the countryside. To some extent this can be mitigated by retaining and laying a few smaller stems, at little extra time or expense.

Hedges that are ready for coppicing or have developed into lines of trees are already a common sight over much of south-west England. As such, the introduction of management for hedge fuel is unlikely to have a major impact on landscape appearance in most areas. It may though reduce the extent of some open views and could potentially make it more difficult to pass along footpaths and other rights of way, as well as creating temporary safety problems on roads. It may also reduce the prominence of mature emergent hedgerow trees, as these blend In with their surroundings.

Recommended action to prevent adverse effects

1. Take a whole farm approach when deciding which hedges to manage for fuel and when to harvest them, backed up by a farm management plan.

2. Before any work begins, assess likely impacts on biodiversity, landscape character, cultural heritage, public access and views, to identify features of particular importance so they can be safeguarded. (The opportunity may also be taken to assess the risk to re-growth from deer, rabbits, etc.

3. Manage no more than half the hedges on a farm through coppicing without any subsequent top trimming. Retain some mature lines of shrubs and trees or allow them to develop. Laying some hedges will help to preserve this traditional skill as well as landscape connectivity.

4. Plan to have a cropping rotation that is between 10 and 20 years in length (depending on species present . This will safeguard bank structure, maintain woody and herb floral diversity and limit any change to landscape character.

5. Introduce any coppice rotation gradually, with no more than 5% of hedges on a farm coppiced in any one year. This will ensure that structural diversity at the farm scale is maintained and help to retain habitat continuity.

6. Retain isolated mature hedgerow trees and keep the shrub line on either side of those with particular aesthetic or biodiversity value short. These trees will include fruit trees, those with significant veteran features (large trunks, rot holes and dead wood and those with important lichen communities. This will both help to maintain local landscape character and to conserve the rich biodiversity associated with open-grown trees.

7. Engage local communities and landowners through information and advice before work starts.

Isolated hedgerow trees like this pollarded ash should not be felled for fuel, especially if they have hollows, rot holes and other veteran features. Such trees are very important for wildlife and landscape. Near Dolton, Devon.

Conclusions

Under the right management, most hedges in south-west England have the potential to produce sustainable and worthwhile woodfuel crops that can reduce farm overheads or help meet the heat energy needs of local communities, or both. Furthermore, though returning a direct economic value to hedges through fuel production, as part of a working landscape, such management creates new rural employment opportunities.

To be cost effective in comparison to other sources of fuel, hedges should normally be harvested by coppicing, the whole trees and bushes being chipped for combustion in woodchip boilers. If labour costs are of less importance, producing logs from hedges when they are either laid or coppiced may be an easier and more practical alternative. Log production is likely to be particularly attractive to local communities working in partnership with farmers to manage hedges.

Cooperative ventures between farmers, or between farmers and their local community groups, are well worth exploring. Woodchips from hedges may, for example, be used to heat local community facilities such as schools, while producing logs can help to alleviate rural fuel poverty.

Scientific names of trees and shrubs

Alder - Alnus glutinosa;
Ash - Fraxinus excelsior;
Beech - Fagus sylvatica;
Birch - Betula species;
Blackthorn - Prunus spinosa;
Elm - Ulmus species;
Field maple - Acer campestris;
Hawthorn - Crataegus monogyna;
Hazel - Corylus avellana;
Oak - Quercus species;
Poplar - Populus species;
Sycamore - Acer pseudoplatanus;
Willow - Salix species.

Well-hedged landscape typical of much of south-west England. Note that although some hedges are cut short, others are developing into lines of trees: managing farm hedges for woodfuel is unlikely to have a major impact on landscape appearance. Near Honiton, Blackdowns, January 2012.

Sources of further information

Four linked reports on wood fuel from hedges by Robert Wolton and a fifth by Robert Wolton and Faye Davey, commissioned in 2012 by the Tamar Valley AONB and Blackdown Hills Project for the EU funded Cordiale project, at www.hedgelink.org.uk/wood-fuel

Wood fuel from hedges: A toolkit for community groups. Dartmoor Circle, 2012. www.dartmoorcircle.org.uk

Whole farm hedge wood fuel assessment tool, for estimating harvestable biomass from different types of hedge www.devon.gov.uk/hedges

For general information on biomass, see Biomass Energy Centre. www.biomassenergycentre.org.uk

Leaflet on the life cycle approach to managing hedges, at www.hedgelink.org.uk/hedgerow-management

For general information on the conservation and management of Devon hedges, see www.devon.gov.uk/hedges

Community groups and farmers can work together to manage hedges and harvest firewood. Participants get exercise, training, social contact and free fuel. South Brent, Devon, March 2013.

Acknowledgements

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He wishes to thank the following for valuable discussion and comments: Andrew Shadrake, Corinna Woodall, Heather Harley, John Whetman, Lisa Schneidau, Rob Dixon, Rosemary Teverson, Ross Dickinson, Sally Westaway and Tom Hynes. Thanks too to the farmers and contractors who helped with the measurement of wood yields from hedges on their land.

Production of the guide was funded by the Tamar Valley AONB, Devon County Council, Lightsource and the Devon Hedge Group.

All photographs were taken by Robert Wolton unless indicated otherwise.

WOOD FUEL FROM HEDGES

How to manage and crop hedges in south-west England for fuel

Flint McCulloch by a 35KW woodchip boiler used to heat his new farmhouse using chips from farm hedges and woods. Lewmoor, Hatherleigh, Devon, April 2012.

John Whetman beside logs harvested from hedges on his farm. Deer Park Farm, near Trusham, Devon, November 2010

PRODUCED BY THE TAMAR VALLEY AONB, DEVON COUNTY COUNCIL AND THE DEVON HEDGE GROUP

The Devon Hedge Group is a forum of organisations and individuals that aims to foster support for hedge conservation in Devon through promoting management that optimises the value of hedges for farming, wildlife, landscape, archaeological and cultural purposes.

Further copies of this guide are available from the Tamar Valley AONB, Tamar Valley Centre, Cemetery Road, Drakewalls, Gunnislake, Cornwall, PL18 9FE.

Printed on 100% recycled paper.

ISBN 978-1-84785-042-3

Design by www.graphicwords.com

£5.00